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HANDOUT 2 – Dating Methods

Glossary

Alpha Particle: positively charged particle given off by certain radioactive substances; consists of two protons and two neutrons.

Amino Acid Racemization: a chronometric dating method once used on bone with dubious results, but now more credibly applied to egg shells (must not be mineralized); measures the ratio of mirror-image D- and L- molecules of amino acids. Living organisms contain only L- “enantiomers,” which racemize to D-enantiomers at a steady rate after death.

AMS Dating: see “Radiocarbon (^{14}C)”; an acronym for Accelerator Mass Spectrometry [also TAMS for Tandem AMS]. The process used in an enhanced radiocarbon dating method that requires only milligram quantities of carbon in a sample to determine a chronometric age.

Archaeomagnetic Dating: a chronometric dating method based on temporal changes in the direction and intensity of the earth’s magnetic field; when heated above the Curie point of $580^{\circ}\text{--}680^{\circ}\text{C}$ ($1076^{\circ}\text{--}1256^{\circ}\text{F}$), clay and clay-rich soils retain a record of the field’s position and strength.

Beetle Gallery: a passage made in wood by a beetle; on trees usually found just beneath outer bark and thus a useful indicator of ring preservation for dendrochronology.

Biota: the animal and plant life of a particular region considered in total.

Bridging Event (E_b): event used to establish a link between a dated event and a target event, e.g. felling of a live tree by a human bridges the death of the tree (E_d) to the construction of a feature (E_c).

Calibration: a measurement or comparison against a standard; adjusting the result from the application of a dating method to yield a date closer to the true calendar age of the sample \pm an error factor. For example, calibrating uncorrected (“raw”) ^{14}C dates to BC/AD calendar ages.

Carbon-14: see *Radiocarbon (^{14}C)*.

Cation Ratio Dating: a dating technique used on rock varnish, based on the ratio: potassium + calcium ÷ titanium; smaller ratio = older. Comparing ratios from different rock surfaces such as petroglyph images is a relative dating technique, but the method also can be chronometric via calibration with AMS ¹⁴C dating. The reliability of cation ratio dates is in dispute.

Chemical Analysis of Bone: a relative dating method that studies the contemporaneity of multiple bone artifacts or ecofacts in a soil stratum or in very similar soil strata; includes the nitrogen, fluorine, & uranium tests.

Chronometric Dating: methods of quantifying time relative to a given scale such as the Christian calendar, typically with an error factor. Often, dates from such techniques are reported in “years BP”, loosely translated as “years **B**efore **P**resent”.

Chronology: the science that deals with time by regular divisions, and that assigns proper dates to events.

Collagen: an insoluble fibrous protein that occurs in vertebrates as a chief constituent of connective tissue as well as in the organic fraction of bone; in the latter case, the preferred material for radiocarbon dating of bone artifacts.

Collateral Dating: additional dates from a site or site’s component for comparison with results of dating a given specimen/feature.

Component: an occupation or set of inseparable occupations within a site, usually defined by associated artifacts and features within a single soil horizon, unit or layer.

Contemporaneity: occurring during the same period of time—a more general concept in archaeology than *simultaneous* or *synchronous*, which applies to events happening at the same point in time. Most chronometric dating techniques yield results with an error factor (\pm # number of years) too large to discern points in time such as specific days or months.

Cross-Dating: placing a component or artifact of a site within a temporal framework by finding it associated with datable material; a set of relative dating methods subdivided into non-cultural (e.g., bone, pollen, geomorphology) and cultural (e.g., trade items, trait resemblances) versions.

Cultural Trait Correlation: relative dating methods that are based on detailed comparative analyses, such as seriation and typology.

Dated Event (E_d): the event that is actually dated by any chronometric technique in a particular situation, e.g., the average age of wood in a burned log or the last time clay was heated to a critical temperature.

Declination: the angle between magnetic north and geographic true north, which varies from region to region as well as through time.

Dendrochronology: a chronometric dating method using tree ring growth patterns to determine the calendar date when a tree died; use of tree trunks and large branches for construction, fuel, etc. makes this concept relevant in archaeology (from Greek *dendron*, tree).

Diachronic: the study of events separated in time, e.g., a diachronic analysis of pottery styles evaluates changes or stability in styles through time.

Diagnostic: indicative, distinguishing, or identified with something; in the case of dating methods, a diagnostic artifact or feature is one that is characteristic of only one time period.

Electron Spin Resonance (ESR): a chronometric dating method similar to thermoluminescence; age determination is based on a count of electrons trapped in minerals during radioactive decay of trace elements. Recent archaeological applications use tooth enamel for sample material.

Fission Track Dating: a chronometric dating method using newly formed rock or glass such as mineral grains in volcanic sediments; one counts the number of etched tracks on a sample surface from the spontaneous fission of uranium 238 impurities (^{238}U half-life = 4.47 billion yrs). Primarily has Old World archaeological applications in sites $\geq 300,000$ years old.

Fluorine Test: a relative dating method using fluorine accumulation to study the contemporaneity of multiple bone artifacts or ecofacts in a soil stratum or in very similar soil strata; *more* fluorine = *older* bone.

Half-life: length of time for half of a radioactive isotope to decay to a stable product; used to calculate ages in “radiometric” dating techniques, & the main factor in determining that technique's time range.

Hydration: the absorption of water molecules, as measured in the obsidian hydration dating technique.

Hydroxyapatite: the main inorganic constituent of bone, formerly used in radiocarbon dating but now known to yield erroneous results.

Inclination: angle of dip of magnetic pole from the horizontal, which varies in time and space with the declination.

Ion: an atom or group of atoms that carries a positive or negative charge as a result of having lost, or gained, one or more electrons.

Isotope: any of two or more species of atoms of chemical elements with the same atomic number & position in the periodic atomic mass or mass number, and with different behavior in the mass spectrograph, in radioactive transformations and in physical properties.

Laser Fusion Argon 40–Argon 39 (^{40}Ar – ^{39}Ar): a chronometric (and radiometric) technique similar to potassium–argon (K–Ar) dating, but requiring a smaller sample of “new” minerals such as those in volcanic ashes. Stable ^{39}K is converted to ^{39}Ar by neutron bombardment, then both Ar isotopes are measured by mass spectrometry; the ^{40}Ar – ^{39}Ar ratio determines the age. This method has mainly geological uses.

Lead Superconductivity: a chronometric dating technique still in the experimental stage, applied to archaeological lead such as in pipes, coins, bottles, etc. The method compares the amount of stable lead to lead corrosion products, based on the fact that lead becomes a superconductor when cooled below 7.2° Kelvin, but the corrosion products do not.

Lichenometry: a dating method using the diameter of lichens that grow in round patterns to determine the date when those lichens colonized a rock surface; comparing lichen diameters on surfaces such as petroglyph images is a relative dating technique, but the method also can be chronometric via calibration with other methods such as AMS radiocarbon.

Luminescence Dating: a range of methods that measure the energy of photons being released. In natural settings, ionizing radiation (U, Th, Rb, & K) is absorbed and stored by sediments in the crystal lattice. With appropriate stimulation, the stored radiation is expelled and released as luminescence. The calculated age is the time since the last exposure to sunlight or intense heat, which bleaches away the

luminescence signal and resets the ‘clock.’ The principal minerals used in luminescence dating are quartz and potassium feldspar. The specific methods lumped under this category include optically stimulated (OSL), photo-transferred (PTTL), and thermal (TL) luminescence.

Nitrogen Test: a relative dating method using nitrogen leaching to study the contemporaneity of multiple bone artifacts or ecofacts in a soil stratum or in very similar soil strata; *less* nitrogen = *older* bone.

Obsidian Hydration: a dating technique using the thickness of hydration layers on surfaces of volcanic glass; thicker hydration rind = older. Comparing hydration rind thicknesses is a relative dating technique, but the method also can be chronometric via calibration with other methods.

Optically Stimulated Luminescence (OSL): a chronometric dating method similar to thermoluminescence, which measures the last exposure of sediment such as quartz sand to sunlight by counting the number of electrons trapped in those sand grains. Samples must be collected in complete darkness. OSL may be done using green light (GSL: on feldspar & quartz), infrared (IRSL: on potassium feldspar), blue light (BSL: on quartz), or red light (RSL: on volcanic feldspar & quartz).

Oxidized Atmosphere: burning situation where the amount of air (specifically, oxygen) is at a normal state, e.g., brown/red pottery & hearths.

Oxygen 18–Oxygen 16 Dating: a chronometric (but *not* radiometric) dating technique based on the ratio of “heavy” (^{17}O & ^{18}O) to “light” (^{16}O) isotopes of oxygen in the calcium carbonate (CaCO_3) of shell-bearing marine animals. The ratio correlates with ocean temperatures as the heavy isotopes are more abundant in colder water; used in paleoclimatic studies.

Paleomagnetism: the study of the position and intensity of the earth’s magnetic field in the past, showing that the field has “reversed” itself in ancient times—which can be used as a chronometric method to date events more than 100,000 years old, thus it has mainly geological uses.

Palynology: the study of “fossil” pollen, including natural accumulations in sediments and archaeological specimens.

Periodization: the process by which an archaeologist accomplishes the delineation of synchronous segments, i.e. figuring out that events took place at different times rather than simultaneously.

Phase: the cumulative archaeological evidence in time and space of all related components; cultural episodes in the history of a region.

Photosynthesis: formation of carbohydrates in the chlorophyll-containing tissue of plants; responsible for the introduction of ^{14}C in vegetal material.

Polster: a clump of moss and attached sediment used as a pollen sample. The texture of the moss surface tends to trap airborne pollen grains, and its consistently moist microenvironment favors pollen preservation.

Potassium–Argon Dating (K–Ar): a chronometric (and radiometric) dating technique using the known rate of decay of ^{40}K (half-life = 1.3 billion yrs) to stable ^{40}Ar that applies to certain minerals in volcanic ash/tuff. Used in Old World archaeological and worldwide geological contexts.

Provenance: the place of origin, such as the volcanic outcrop where obsidian nodules are procured for stone tool manufacture.

Provenience: the three-dimensional location (N-S \times E-W \times depth) of an archaeological artifact, feature or ancillary sample.

Qualitative: of, relating to, or involving quality or kind; analysis designed to identify components.

Quantitative: involving the measurement of quantity or amount.

Quartz Hydration: a dating technique using the thickness of hydration layers on quartz surfaces; as in obsidian hydration (above), thicker hydration rind = older sample. Currently in the experimental stage with an estimated time range of 100–100,000 years; the hydration process is apparently temperature-dependent as well.

Radiocalcium (^{41}Ca): a chronometric (and radiometric) dating technique using the known rate of decay of ^{41}Ca (half-life = 103,000 yrs) in bone or other Ca-rich materials up to 1,000,000 yrs old; collected samples must have been *deeply* buried (≥ 3 m) since the period of archaeological interest.

Radiocarbon (^{14}C): an isotope of stable ^{12}C , produced by a combination of nitrogen and a neutron. It acts like ^{12}C and enters the carbon dioxide of the atmosphere. A chronometric (and radiometric) dating technique uses the known rate of decay of ^{14}C (half-life = 5730 yrs), which applies to any plant or animal matter.

Radiometric: chronometric dating techniques that are based on the decay of a radioactive isotope into a stable one, such as radiocarbon or potassium-argon dating.

Reduced Atmosphere: a burning situation where the amount of air (specifically, oxygen) present is reduced or eliminated.

Reference Event (E_r): the potentially datable event that is most closely related to the phenomenon to which the date is to be applied, e.g., critical temperature attainment or death of an organism.

Relative Dating: determination of the correct order of events; no exact calendar age available, e.g., the chemical dating of bone.

Rhenium–Osmium Dating (Re–Os): a chronometric (and radiometric) dating technique using the known rate of decay of ^{187}Re (half-life = 45 billion yrs) to stable ^{187}Os in certain rocks & minerals; mainly geological uses.

Seriation: sequence dating, or the ordering of phases/artifact types from earliest to latest; a relative dating technique commonly used in southwestern Colorado with ceramic type frequencies.

Site: any location with physical evidence (artifacts and/or features) of past human activity.

Skeleton Plot: in dendrochronology, the comparison of the rings of one wood specimen with another via a graph that exhibits the relative widths of diagnostic rings.

Standard Deviation: statistically-derived probability or “error factor” that a specific result falls within a given value range. For example, with a ^{14}C date reported as 2000 ± 100 BP, the 100 year error factor is one standard deviation (or one sigma, σ) meaning there is a 68% probability that the age of the dated sample is between 2100 and 1900 BP. By doubling the error factor to 200 years, the probability that the age falls in the 2200–1800 BP time range increases to 95%.

Stratigraphy: the study of rock or soil layers; the layering principle in archaeology and geology: a deeply buried stratum is older than strata above it, except in certain disturbed contexts; a relative dating technique.

Synchronic: the study of events that appear to be contemporaneous at some level, i.e., an archaeological analysis focusing on a single point in time.

Target Event (E_t): the event to which the date is to be applied by the chronometrician or other scientist, e.g. behavioral events in the history of a human society.

Thermoluminescence (TL): a chronometric dating method measuring the re-accumulation of electrons trapped in the crystal lattice of certain soil minerals; heating above ca. 400° C (752° F) releases all trapped electrons. Most archaeological applications have been with ceramic artifacts.

Thermoremanent Magnetism: alignment of magnetic particles by heating above a material's Curie point, e.g. above 580° C (1076° F) for magnetite.

Typology: the systematic organization of artifacts into categories of classes (e.g., *metate*) and types (e.g., *trough metate*) based on shared attributes; used as a relative dating technique when types of artifacts or features are chronologically “diagnostic.”

Uranium Series Dating: chronometric (and radiometric) dating techniques using the decay of uranium in materials such as limestone or travertine altered by ground-water in solution caverns; these methods determine age by the degree to which equilibrium has been restored between parent and daughter isotopes, *not* by measuring stable decay products. Two such methods involve Uranium–Thorium dating: ^{234}U – ^{230}Th with half-lives of 246,000 & 75,400 yrs, respectively; and ^{238}U – ^{232}Th with half-lives of 4.47 billion & 14.5 billion yrs, respectively. Useful on samples up to 500,000 years old.

Uranium Test: a relative dating method using uranium accumulation to study the contemporaneity of multiple bone artifacts or ecofacts in a soil stratum or in very similar soil strata; *more* uranium = *older* bone.

Varve Dating: a chronometric dating method using banded glacial outwash deposits (varves, from Swedish *varv* = layer) to count back in time, two bands per year (1 coarse band + 1 fine band = 1 varve).